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BENEFICIATION OF STAUROLITE FROM BARRIE TOWNSHIP, SOUTH EASTERN ONTARIO

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BENEFICIATION OF STAUROLITE FROM BARRIE TOWNSHIP, SOUTH EASTERN ONTARIO

by

P.R.A. Andrews* and W. Kelly**

ABSTRACT

A sample of staurolite was processed using air tabling, magnetic separation and sizing techniques to produce a product suitable as sandblasting material. Products from the various beneficiation procedures were evaluated qualitatively; preliminary indications are that satisfactory staurolite concentrates could be produced. Final verification of their suitability as sandblasting material would require product evaluation. The production of specification grade staurolite also would require more intensive beneficiation, possibly a combination of both dry and wet benefication techniques to remove impurities.

Keywords: staurolite, air tabling, magnetic separation, sizing, sandblasting

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ENRICHISSEMENT DE LA STAUROLITE DU CANTON DE BARRIE DANS LE SUD-EST DE L'ONTARIO

par

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RÉSUMÉ

Un échantillon de staurolite a été traité au moyen de techniques de tablage à l'air, de classement magnétique et de calibrage pour être transformé en un produit de sablage. Les produits des diverses méthodes d'enrichissement ont été évalués qualitativement; les premiers résultats indiquent qu'il est possible de produire des concentrés de staurolite satisfaisants. Pour vérifier (contrôle final) si ces concentrés conviennent comme matériau de sablage, il faudrait pouvoir évaluer les produits. La production de staurolite de qualité "spécification" nécessiterait aussi un enrichissement plus poussé, peut-être une combinaison de techniques d'enrichissement par voie tant sèche qu'humide pour en éliminer les impuretés.

Mots clés : staurolite, tablage à l'air, classement magnétique, calibrage, sablage.

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INTRODUCTION

Selected split drill core samples (BQ) weighing approximately 15 kg from the Hardie property, Barrie township, Frontenac county, Southeastern Ontario were supplied by Sar-O-Lite Exploration Ltd. A preliminary investigation was requested to explore the possibility of obtaining a product suitable for the sandblasting market.

SAMPLE DESCRIPTION

General geology

The Hardie prospect is located in the central medisedimentary belt of the Grenville province. The sample received was a light-to medium-gray porphroblastic staurolite-garnet-schist of the Bishop's corners formation. The rock displayed a weak to strong schistosity, which is approximately 60° to the core axis; head analyses vary from 15% - 30% staurolite-garnet.

Mineralogy

A representative head sample obtained from the crushed drill core was submitted for X-ray diffraction; results are reported in Table 1. The head sample was subsequently sized and each fraction examined optically to determine mineral identity, association and liberation; results are reported in Table 2.

PROCESSING

Size reduction

Core samples were stage-crushed by jaw and roll crushing to 2.4 mm. Further size reduction to 420 µm, the estimated liberation size, was effected by hammer milling and ring pulverising. The resulting size distribution is as follows:

Size fraction	Weight
µm	%
-420 + 150	53.6
-150	46.4
	100.00

The -420 + 150 µm fraction, weighing approximately 8 kg, was riffled into four 2 kg batches for further evaluation. The -150 µm fraction being low grade, was discarded.

Air classification

A 2 kg sample of -420 + 150 µm material was passed over a Denver laboratory air table with the objective of separating muscovite and biotite from staurolite. The results are presented in Table 3.

Electrostatic separation

A 2 kg sample of -420 + 150 µm material was passed over a laboratory Carpco electrostatic separator with the objective of separating staurolite, a non-conductor from magnetite, a conductor. The results are reported in Table 4.

Magnetic separation

A 2 kg sample of -420 + 150 µm material was passed over the Eriez perm-roll magnetic separator to remove the principal magnetic minerals, biotite, magnetite, garnet and staurolite. The magnetic portion was then passed over a Denver air table to remove the micaceous minerals and to concentrate the staurolite. Results of these tests are presented in Table 5.

Size concentration

A 2 kg sample of - 420 + 150 µm material was sized on several sieves between 420 µm and 150 µm to determine whether there was a concentration of staurolite in any particular size fraction. Results and observations are reported in Table 6.

RESULTS

Air classification

Air tabling results indicate that micaceous minerals can be efficiently removed, thus producing a higher grade staurolite pre-concentrate. The results in Table 3 indicate that 25% of head material can be removed. There is, however, a substantial amount of middling, 42.2% weight, which contains

10% staurolite. Subsequent re-treatment of middlings, as demonstrated in Table 5, can only upgrade staurolite to 60% which is below the 89% staurolite sandblasting specification (1). Consequently, although air tabling can produce an 80% grade staurolite/garnet concentrate, the presence of lower grade staurolite middlings would indicate that air tabling alone cannot produce specification grade staurolite.

Electrostatic separation

The electrostatic separation of staurolite from magnetite is based on the fact that magnetite is a conductor and staurolite a non-conductor, even although both are magnetic. The magnetite is removed during the initial pass leaving the staurolite and other remaining gangue minerals. This product, free from magnetite, is then heated to 650°C for one hour and cooled to a temperature from 50°C to 100°C. The heating and cooling treatment is claimed (2) to convert staurolite to a conductor, while the micaceous minerals remain as non-conductors. Re-treatment of the staurolite product separates the staurolite from the micaceous minerals.

The results noted in Table 4, indicated that although there was a minor concentration of staurolite, there was no visible separation of staurolite from magnetite. However, the micaceous minerals were effectively separated from both staurolite and magnetite. Since staurolite and magnetite were not separated, it was decided not to pursue the heat treatment study further.

Magnetic separation

A good separation was achieved between the mafic and non-mafic minerals, but approximately 20% biotite with a minor amount of muscovite was retained in the magnetics. Separation of the micaceous minerals was subsequently achieved by air tabling.

The first pass over the Denver Air table yielded a fairly good separation, but with a high percentage of middlings, 52.8% weight (relative), containing approximately 15% staurolite. After a second pass, an additional concentrate containing 65 to 70% staurolite/garnet, representing 17.9% weight (relative),was recovered resulting in a combined cocentrate of 52.7% weight (relative). The combined tailing accounts for 15.6% weight (relative), which still leaves 31.7% weight (relative) as the middling product containing an average of 10 to 15% staurolite.

Size concentration

The results in Table 6 indicate that there is a definite concentration of staurolite in the +210 µm size fraction. The average grade of staurolite in the -210 µm fraction, by contrast, is only approximately 2 to 3%. Establishing an optimum grind will remove as much as 45 to 50% weight of material to produce a pre-concentrated product.

COMMENT

Although dry beneficiation techniques, specifically air tabling and sizing, produced high grade staurolite concentrates, these concentrates did not meet the 89% staurolite specification for sandblasting. Production of specification grade staurolite may be possible by a combination of wet and dry beneficiation techniques. The wet treatment route typically involves grinding, screening and spiral concentration to concentrate the heavy minerals. The pre-concentrated heavy minerals are dried and the staurolite removed as a magnetic fraction after first removing the titanium minerals by a combination of electrostatic and magnetic separation.

CONCLUSIONS

A mainly qualitative study based on the sample as received has indicated that high-grade staurolite concentrates can be produced. A product evaluation for sand-blast application is necessary to determine whether staurolite from this deposit is suitable for this purpose.

RECOMMENDATIONS

1. A market study should be conducted to establish size and variety of markets, competition from substitute materials, and product specifications and requirements pertaining to the type and percentage of acceptable deleterious material.

2. Cost benefit analysis should be conducted to establish cut-off grade.

3. Additional diamond drilling should be undertaken to determine ore grade and extent of deposit.

4. Further testwork at the laboratory and possibly pilot-plant level should be conducted to establish optimum processing parameters.

5. A product evaluation comparing the effectiveness of the staurolite concentrates with standard quartz sand to determine sand-blast efficiency should be carried out.

REFERENCES

1. Fulton R.B. III., "Staurolite"; Industrial Minerals and Rocks 4th edition; pp 1225-1227; AIME Mudd series; 1975.

2. Fraas F., 'Electrostalic separation of granular materials'; U.S. Bureau of Mines Bulletin 603; p 110; 1962.

Table 1. Modal analysis of staurolite sample

Mineral	Description	Weight % Approximate
staurolite	light brown	20
garnet	pyrope/spessontite variety	10
magnetite	-	10
quartz	clear	50
muscovite/biotite	-	10
chlorite	green	trace
pyrite	-	trace

Table 2. Optical examination of head sample size fractions

Size fraction μm	Weight %	Description
+1200	23.6	compound grains, aggregates of quartz, staurolite, biotite, muscovite, garnet, magnetite, chlorite and a trace of pyrite. No liberation.
-1200+840	12.1	reduction of compound grains is greater, but no liberation.
-840+600	9.6	minor liberation, garnet and staurolite grains are angular with hackly, chisel-type fracture.
-600+420	6.9	some as above with a fair amount of liberation.
-420+300	5.6	fair to good liberation.
-300+210	5.3	good liberation
-210	36.9	minor concentration of staurolite, possibly less than 5% and probably 150 μm in size.
Total	100.0	

Table 3. Denver air table test to remove micaceous minerals

Products	Weight %	Description
Tailings	25.1	essentially 100% mica with minor quartz and <1% staurolite.
Middlings	42.2	quartz, 15% mica, 10% staurolite, trace garnet and minor magnetite.
Concentrate	32.7	30% quartz, 55% staurolite, 5% garnet, 6% magnetite and 1% mica.
Total	100.0	

Table 4. Carpco electrostatic separation test

Products	Weight %	Description
Concentrate	26.6	50% quartz, 5% magnetite, 40% staurolite, 5% garnet; trace pyrite, chlorite, muscovite and biotite.
Middlings	47.8	80% quartz/mica, 15% staurolite; trace magnetite, chlorite and pyrite.
Tailings	25.6	90% micaceous minerals, 10% quartz; trace staurolite and garnet.
Total	100.0	

Table 5. Magnetic separation and air tabling combined test

Products	Weight % (actual)	Weight % (relative)	Description
Magnetics	59.6	-	≈ 20% micaceous minerals.
Non-magnetics	40.4		
Total	100.0		
Air table concentrate #1	20.7	(34.8)	70-75% staurolite, 5% garnet, 10% magnetite, 5% quartz with trace muscovite and biotite.
Air table middling #1	31.5	(52.8)	increasing amount of staurolite and garnet ≈ 15%.
Air table tailing #1	7.4	(12.4)	98% micaceous minerals with minor quartz.
Total	59.6	(100.0)	
Air table middling #1 (repassed)			
Air table concentrate #2	10.8	(17.9)	60% staurolite/garnet, 20% quartz, 9% magnetite, and 6% biotite/muscovite.
Air table middling #2	18.8	(31.7)	50% biotite, 7% staurolite/garnet, 20% quartz, 1% magnetite.
Air table tailings #2	1.9	(3.2)	biotite and muscovite with minor quartz.
Total	31.5	52.8	

Table 6. Distribution of staurolite in the -420+150 µm fraction

Size fraction µm	Weight %	Description
-420+210	45.0	predominantly staurolite
-210+150	55.0	= 2 to 3% staurolite.